RICE BRAN OILMETHYL ESTER (ROME)AS AN ALTERNATIVE FUEL FOR CI ENGINE: REVIEW

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ABSTRACT

The increased attention on alternative fuels in the recent years was mainly driven by increasing oil prices, strong emission norms and the concern on clean environment. The biodiesel has emerged as a potential substitute for diesel fuel on account of its renewable source and lesser emissions. Biodiesel is a renewable and environmental friendly alternative fuel which can be used as a substitute for diesel in compression engine without any modifications. Biofuels have the potential to become alternative fuel for fossil fuels. Among all the alternative fuels rice bran oil biodiesel is also one. This review has been taken up to identify the performance, combustion and emission using rice bran oilmethyl ester.

Keywords: *Rice bran oilmethyl ester, blends, CI engine, performance, combustion, emission.*

1. INTRODUCTION

In order to meet the energy requirements, there has been growing interest in alternative fuels like biodiesels, alcohol, biogas, hydrogen and producer gas to provide a suitable diesel oil substitute for internal combustion engines. Vegetable oils present a very promising alternative to diesel oil since they are renewable and have similar properties. Vegetable oils offer almost the same power output with slightly lower thermal efficiency when used in diesel engine. Furthermore, contribution of bio-fuels to greenhouse effect is insignificant, since carbon dioxide (CO_2) emitted during combustion is recycled in the photosynthesis process in the plants. Alternative fuels should be easily available at low cost, be environment friendly and fulfill energy security needs without sacrificing engine's operational performance. For the developing countries, fuels of bio-origin provide a feasible solution to the twin crises of fossil fuel depletion and environmental degradation. Vegetable oils and their derivatives in diesel engines have a higher cetane number than diesel because of long chain fatty acids with 2-3 double bonds, heat of vaporization, and stoichiometric air/fuel ratio with mineral diesel. In addition, they are biodegradable, non-toxic; it has no aromatics and contains 10– 11% oxygen by weight. Rice bran oil is a non-conventional, inexpensive and low-grade vegetable oil. Crude rice bran oil is also source of high value added by-products. Thus, if the by-products are derived from the crude rice bran oil and the resultant oil is used as a feedstock for biodiesel, the resulting biodiesel could be quite economical and affordable.

2. TRANSESTERIFICATION REACTION

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification.

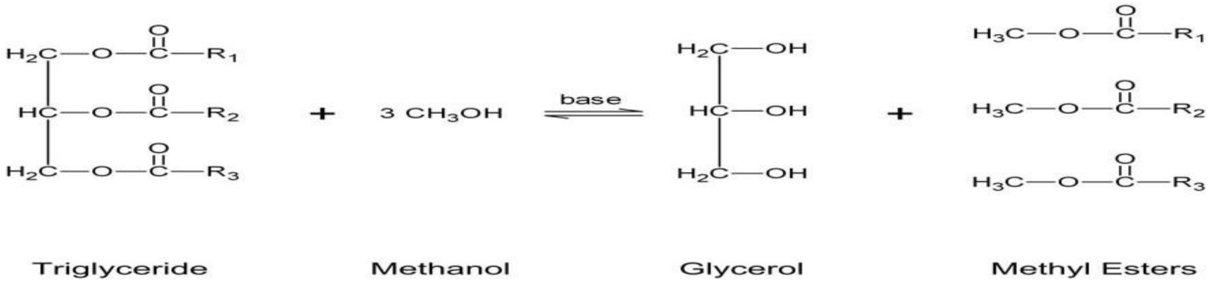

Fig-1: Chemical reaction

3. PROPERTIES OF FUELS

Properties	Diesel	Rice bran oil methyl ester (ROME)
Kinematic viscosity at 40˚C (cSt)	2.7 – 3.4	4.63 – 7.96
Specific gravity at 20˚C	0.82	0.87
Flash point (˚C)	56 - 71	165 - 176
Calorific value (MJ/kg)	42 – 43.5	34.11 – 38.7

Table-1: Properties of diesel and rice bran oilmethyl ester

4. LITERATURE REVIEW

1. Umesh T., Manjunath H. N., Rukmangadha P., Dr. Madhu D [1]

Conducted experiments on performance & emission analysis of Rice bran oil as an alternative fuel for an I.C.engine. In this work, different blends of Rice bran biodiesel and diesel were prepared such as B10, B20, B30, B40, B50, B100 andexperiments were conducted on a 4-cylinder direct-injection diesel engine. The engine speed was maintained at 1500 rpm.

Results showed that, the brake thermal efficiency increased as the load on the engine increased. The brake thermal efficiency of the B20 Blended fuel was highest than the all other fuels. The brake thermal efficiency decreased as the proportion of rice bran oil increased. The brake specific fuel consumption reduced with increase in brake power for all fuel modes. The brake specific fuel consumption of the B20 blend was much less when compared to diesel and other blends. As the proportion of rice bran oil increased in the blends, specific fuel consumption increased. The CO_2 emissions increased with increase in brake power for all the fuel samples as the loads increases. The CO_2 emission for diesel and B10 were higher at the higher brake power than the other blends. The lowest CO_2 emissions were observed for B40. The hydrocarbon emission increased with the increase in brake power. At the higher brake power, the hydrocarbon emission for the B50 was less, compared to the conventional diesel and other blends. The NO_X emission for diesel and all the blends followed increasing trends with respect to the brake power. For diesel and B10 showing the higher NO_X emission. NO_X emissions decreased with the increase of addition of rice bran oil in the blends.

2. Jasanpreet Singha, Narinder Kumarb, S. K. Mahlac [2]

Conducted experiments on Rice Bran oil biodiesel as an alternative in single cylinder CI engine with DI Ethyl Ether blends. In this work, an experimental investigation has been carried out to analyze the performance and emission characteristics of a compression ignition engine fuelled with rice bran oil and its blends (5%, 10% and 15%) with di ethyl ether at different load conditions.

Results showed that, the power of engine increases with the amount of rice bran oil and blend in the fuel. At full load condition, the rice bran oil of 5%, 10% and 15% blends produce 6.2%, 8.7%, 11.6% and 10.6% higher brake thermal efficiency than sole diesel respectively. The 10% gave good result in terms of brake thermal efficiency as compared to rice bran all other blends. The BSFC for all the fuel blends tested decreases with increase in load. For blends with oxygen fuel greater than 10%, the BSFC was observed to be greater than that of diesel. CO emissions decreases as the wt.% oxygen was increased, for each load, for the 5 wt.% and 10 wt.% oxygen by DEE-RBO blends the change was not much but with increase in % the decrease was significant. As the proportion of oxygen was increased, the reduction in HCs increases due to the ethanol increase within the blend. Rice Bran Oil and Di ethyl Ether blends produce lower smoke levels than their diesel counterparts for corresponding speed load conditions.

3. Dhanesh C., Arunkumar G., Anantha Raman L., Vivek M., Santhoshkumar A [3]

Conducted experiments on Rice bran oil biodiesel: an alternate fuel for CI engine. In this work, rice bran oil obtained from rice milling was used for biodiesel preparation. The engine used for testing was kirloskar make, single cylinder, direct injection, water cooled engine coupled with electrical dynamometer.

Results showed that, brake thermal efficiency has the tendency to increase with increase in applied load. The BTE of the biodiesel was lower than the diesel in all the loads starting from no load to full load. At maximum load, the brake thermal efficiency of the biodiesel fuel was 8.7% lower than diesel and at 50% load the brake thermal efficiency was 15% lesser than diesel. The exhaust gas temperature increases with increase in load. The rice bran oil methyl ester produces higher exhaust gas temperature than diesel. At zero load and minimum load, the exhaust gas temperature of biodiesel was 7.45 and 17.54% higher than diesel respectively. The specific fuel consumption of rice bran oil methyl ester was higher than that of diesel in all loads. At maximum load and 50% load, the brake specific energy consumption was 23% and 15.2% lower than diesel respectively. Rice bran oil methyl ester produces a maximum pressure of 62.41 bar, which was 6.9% lower than the diesel fuel. While using biodiesel as a fuel, the unburned hydrocarbon emission decreases. At no load condition, the biodiesel produce 9.2% lower UBHC emission than diesel fuel and at maximum load, it produce 8.3% lower UBHC than diesel. The CO emission gradually increases with increase in load. The CO emission of rice bran oil methyl ester was lower than diesel for all the load condition. The smoke emission increases with increase in load. Rice bran oil methyl ester produces 10.52% lesser smoke emission than diesel at maximum load. Also, at minimum and 50% load, the biodiesel produces 44% and 21.1% lower than diesel respectively.

4. Hariram. V., Shanil George Chandy [4]

Conducted experiments on influence of injection timing on combustion and heat release parameters using biodiesel of Neem, Rice bran and Pongamia in a direct injection compression ignition engine. In this work, the three biodiesel were blended in 5%, 10% and 15% ratios.

Results showed that, peak pressure for Neem 5%, 10% and 15%, Rice bran 5%, 10% and 15%, Pongamia 5%, 10% and 15% biodiesel blends at standard injection timing (334 CAD) showed 59 bar, 62.5 bar, 66 bar, 60 bar, 63 bar, 67 bar, 61 bar, 64 bar and 68 bar pressure respectively with standard injection timing at part load condition while advancing the injection timing by 6 CAD represents 3% to 4% increase in in-cylinder pressure (i.e.) 60 bar, 63 bar and 67 bar for Neem, 61 bar, 64 bar and 68 bar for Rice bran and 62.5 bar, 65 bar and 70 bar for Pongamia blends respectively at full load condition. Pongamia blends showed 2% to 3% higher combustion pressure when compared with Neem and Rice bran. Pongamia 15% blend showed 70 bar and 67.5 bar in-cylinder pressure at full and part load respectively. At no load and low load condition, the in-cylinder pressure for diesel and blends of Neem, Rice bran and Pongamia were almost similar at standard and advanced injection timing but retarded injection timing showed 2% to 3% reduction in combustion pressure. The in-cylinder pressure for Neem, Rice bran and Pongamia at part and full load with retarded injection timing represents 4% to 6% negative improvement in peak pressure. Pongamia 15% blend shows 4% to 5% positive improvement in in-cylinder pressure at part load and full load condition with advancement of injection timing by 6 CAD. At standard injection timing, the rate of heat release was 3% to 4% higher for blends of biodiesel than diesel. Advancing the injection timing by 6 CAD showed positive improvement in rate of heat release for blends of biodiesel by 6% to 8%. The rate of heat release was higher for Pongamia biodiesel at any injection timing and load. Blends of Rice bran biodiesel also showed 2% to 3% increase in rate of heat release but lower that Pongamia biodiesel. Retardment of injection timing by 6 CAD for Neem, Rice bran and Pongamia blends exhibits reduction in rate of heat release when compared with standard and advanced injection timing.

5. Sharanappa Godiganur, R. P. Reddy [5]

Conducted experiments on performance and emission study of Rice Bran oil methyl ester in a 4-stroke natural aspirated direct injection diesel engine. In this work, investigations carried out in studying the fuel properties of rice bran methyl ester (ROME) and its blend with diesel from10% to 50% by volume and in running a diesel engine, incorporated with eddy current dynamometer with these fuels.

Results showed that, BSFC decreased sharply with increase in load for all fuels. The BSFC for all blends were higher than that of diesel. BSEC decreased sharply with increase in percentage of load for all fuels. BTE increased with increase in load. The maximum thermal efficiency for B20 (30.82%) was higher than that of diesel. The BTE obtained for B10, B20, B30, B40 and B50 were less than that of diesel. The EGT increased with increase in engine loading for all the fuel tested. The mean temperature increased linearly from 144°C at no load to 187°C at full load condition. The EGT was found to increase with the increasing concentration of biodiesel in the blend. The minimum (B50) and maximum (B10) CO produced at full load were 0.07, 0.012% resulting in a reduction of 48% and 11%, respectively, as compared to diesel. The CO initially decreased with load and later increased sharply up to full load. Engine fuelled with ROME, the emissions of HC considerably reduce when compared with those where diesel was used. When engine fuelled with 50% ROME, HC emissions decrease by 24% in comparison with those where diesel was used. The amount of NOx produced for B10 to B50 varied between 65 and 371 ppm as compared to 44 to 339 ppm for diesel. The increasing proportion of biodiesel in the blends was found to increase NO_X emissions slightly (within 9.4%) when compared with that of pure diesel.

6. Wahome A., Ngunjiri G. M. N., Shitanda D., Ogola W. O [6]

Conducted experiments on performance characteristics of blended Rice Bran biodiesel in a diesel engine. In this work, the engine performance was studied using a single cylinder four stroke engine and

EA10 dynamometer using diesel as a control and biodiesel blends of 5:95, 10:90, 15:95,20:80, 25:75, and 30:70 biodiesel to diesel respectively.

Results showed that, brake power increased linearly with increased load for all the fuel samples up to 7kg as brake power is directly proportional to load and speed. The average brake power for diesel was 2.628 kW while that of biodiesel was 2.682 kW an increase of 2.1%. The engine brake power increased with the biodiesel content in the blend with B5 having an average of 2.636 kW an increase of 0.3% compared to diesel and B30 having an average of 2.648 kW an increase of 0.76% compared to that of diesel. The engine torque increased linearly with increase in load. Further increase in torque beyond the maximum load of 7kg, slowed the engine to a stop. BSFC reduced with increase in load, the average BSFC being 0.485 kg/kW-hr and 0.712 kg/kW-hr for diesel and biodiesel respectively. The BSFC of diesel, biodiesel and their blends reduced with increase in brake power for all the fuels. The BSFC of the fuel samples was also found to increase with increase in the proportion of biodiesel content in the blend. The average BSFC of blend B5 was 0.549 kg/kW-hr, which amounted to 13.2% increase in BSFC compared to diesel. The brake thermal efficiency of the engine increased with increase in brake power. The brake thermal efficiency of all the blends followed the same trend as that of diesel and biodiesel respectively.

7. Sunil I. Patel, Dipak C. Gosai, Vandana Y. Gajjar [7]

Conducted experiments on performance and exhaust emission analysis of thermal barrier coated diesel engine using Rice Bran oil biodiesel. In this work, the effects of coating on the performance of engine using rice bran oil biodiesel blends of B10, B20, B40, B100 with the diesel fuel.

Results showed that, fuel consumption of the fuel increased with load for all fuel modes. The fuel consumption of rice bran biodiesel blends (B10, B20, B40, B100) were higher than that of the conventional diesel fuel over the entire range of the brake power. The maximum fuel consumption increase (10-20%) was at the full load of B10, B20, B40, B100 than the diesel fuel. The specific fuel consumption (SFC) reduced with brake power for all fuel modes. In comparison of diesel a slightly increased (10-15%) of SFC was found for rice bran biodiesel blends B10, B20, B40, B100 through all loads. SFC of B100 was found higher in comparison to the other blends in all loads. The mechanical efficiency increased with load for all fuel modes. Mechanical efficiency of the different blends B10, B20, B40, B100 were lower than that of the diesel fuel. The maximum increased efficiency was found (10-15%) at 100% diesel fuel than the biodiesel blends B10, B20, B40, B100. The brake thermal efficiency increased with brake power for all fuel modes. The brake thermal efficiency of rice bran biodiesel blends B10, B20, B40, B100were (5%) lower than that of the diesel fuel with respect to all loads. The indicated thermal efficiency increased with brake power for all fuel modes. The indicated thermal efficiency of diesel fuel was lower than rice bran biodiesel blends B10, B20, B40, B100. The maximum indicated thermal efficiency (44.8%) was for B100 at 3.3 kW brake power. The heat loss by the exhaust gases was only 10.12% as compare to other losses. The maximum loss was found in the uncoated region 46.24% as compared to other losses. HC increased with brake power with all fuel modes. Rice bran biodiesel and its different blends B10, B20, B40 showed lower HC (50-60%) than diesel fuel. HC percentage decreased with blending percentage increased. B100 produced lowest HC emissions among all fuels and were (50-60%) lower than diesel fuel. The CO emissions slightly increased at low and medium loads and increased significantly at higher loads with all fuel modes. The CO emissions of the different blends B10, B20, B40, B100 were found lower as compared to diesel fuel at full load of the engine. The NO_X emissions of biodiesel blends B10, B20, B40, B100 were less at low loads and more at medium and high loads than those of diesel fuel. The percentage reduction of NO_X decreased with increased of brake power. NO_X values at maximum load (4.62 kW) were found that, diesel-970, B10-910, B20-860, B40-800 and B100-600 ppm.

8. S. S. Naga Prakash Chokka, Y. Dhanasekhar, M. V. H. Satish Kumar [8]

Conducted experiments on performance and emission characteristics of transesterificated biodiesel-an experimental approach with Diesel-Rice Bran biodiesel blends.In this work, different proportions of blends such as RB20, RB30, RB40, RBE20, RBE30, RBE40 to find out the performance parameters and emissions. Tests also include engine with ethanol and Ethyl Hexyl nitrate as additives to the diesel-biodiesel blends. Ethanol was added as 10% by volume to the diesel, biodiesel blends and ethyl Hexyl Nitrate was added 2% to the diesel-bio diesel blends.

Results showed that, as load increases brake thermal efficiency was increases for diesel as well as the blends of rice bran oil. At full load condition, the brake thermal efficiencies were obtained 25.96%, 24.72%, 25.83%, 26.45%, 27.47%, 29.87% and 23.7% for fuels of diesel, RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. Among the six blends of Rice bran oil the maximum BTE is 29.87% which was obtained for RBE30. As load increases mechanical efficiency was also increases for diesel as well as the blends of rice bran oil. At full load condition the mechanical efficiencies obtained 70.11%, 71.48%, 73.34%, 69.66%, 67.43%, 79.76% and 57.09% for fuels of diesel, RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The mechanical efficiency of Rice bran blend RBE30 increases with compared diesel at full load condition. As the load increases the fuel consumption decreases. At full load condition the BSFC obtained were 0.34 kg/kW-hr, 0.35 kg/kW-hr, 0.35 kg/kW-hr, 0.35 kg/kW-hr, 0.34 kg/kW-hr, 0.33 kg/kW–hr and 0.35 kg/kW-hr for fuels of diesel, RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The minimum fuel consumption was for RBE40 was 0.36 kg/kW-hr. As the load increases the indicated power decreases. At full load condition the Indicated Power obtained were 6.27 kW, 6.15 kW, 5.99 kW, 4.85 kW, 4.59 kW, 4.33 kW and 7.70 kW for fuels of diesel, RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The engine emits more CO for diesel as compared to biodiesel blends under all loading conditions. At full load condition the CO emission obtained were 0.45%, 0.61%, 0.77%, 0.67%, 0.62%, 0.59% and 0.07% for fuels of diesel RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The CO concentration was decreases for the blends of RBE30 with compared to diesel and all other blends. As the load increases the CO_2 emission decreases. At full load condition the CO_2 emissions obtained were 7.8%, 7.7%, 7.5%, 7.2%, 6.9%, 5.3% and 7.9% for fuels of diesel, RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The CO_2 emissions of rice bran oil blend RBE20decreased when compared to the diesel at full load condition. As the load increases the HC emission decreases. At full load condition the unburned hydrocarbons were obtained as 40ppm, 42ppm, 38ppm, 39ppm, 37ppm, 19ppm and 47ppm for fuels of diesel, RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The HC emission of rice bran oil blend RB20 decreased when compared to the diesel at full load condition. As the load increases the NO_X emission decreases. At full load condition the NO_X emissions obtained were 592ppm, 579ppm, 541ppm, 875ppm, 783ppm, 530ppm and 971ppm for fuels of diesel, RB20, RB30, RB40, RBE20, RBE30 and RBE40 respectively. The NO_X emission of Rice bran oil blend RBE30 decreased when compared to the other blends at full load condition.

9. G. Venkata Subbaiah, K. Raja Gopal, Syed Altaf Hussain, B. Durga Prasad & K. Tirupathi Reddy [9]

Conducted experiments on Rice Bran oil biodiesel as an additive in diesel-ethanol blends for diesel engines. In this work, experimental investigation was carried out on the performance and exhaust emission characteristics of a direct injection (DI) diesel engine when fuelled with conventional diesel fuel, rice bran oil biodiesel, a blend of diesel and rice bran oil biodiesel and three blends of diesel-biodiesel-ethanol over the entire range of load on the engine.

Results showed that, the brake thermal efficiency of rice bran oil biodiesel (B100), blend of diesel and 10% biodiesel and all diesel-biodiesel-ethanol blends was higher than that of the conventional diesel fuel over the entire range of the load. The brake thermal efficiency was increased by 1.5%, 2.2% and 2.91% respectively with 5%, 10% and 15% of bioethanol in diesel-biodiesel-ethanol blends compared with the blend B10. The maximum brake thermal efficiency was observed with B10E15 at all the loading conditions of the diesel engine and it was 3.67%, 0.7% and 2.92% higher than that of diesel fuel, B100 and B10 respectively at full load of the engine. The BSFC of B100 and B10 were 24.43% and 3.7% higher than that of the diesel fuel at full load of the engine. The BSFC increased by 23.27%, 27.63% and 31.63% respectively with the blends B10E5, B10E10 and B10E15 compared with the blend B10. The exhaust gas temperature of the blend B10 was 9.56% higher than that of diesel fuel and 22.36% lower than that of the biodiesel (B100). The increase of the ethanol percentage in the diesel-biodiesel-ethanol blends reduced the exhaust gas temperature. The reduction was 2.93%, 4.53% and 6.93% lower than that of the blend B10 respectively with the blends B10E5, B10E10 and B10E15. The CO emissions reduced with increase of ethanol percentage in the diesel-biodiesel-ethanol blend. The CO emissions reduced by 46.39%, 51.54% and 54.63% than the conventional diesel with the addition of 5%, 10% and 15% of ethanol in diesel-biodiesel-ethanol blends. Among the diesel-biodiesel-ethanol blends the blend of 75% diesel, 10% biodiesel and 15% ethanol produced the lowest amount (0.44% volume) of CO emissions at full load of the engine. The HC emissions increased with increase of ethanol percentage in the diesel-biodiesel-ethanol blends. The HC emissions were 48.8%, 34.3% and 40.0% lower than those of diesel fuel with 5%, 10% and 15% of ethanol addition at full load of the engine. Among these blends, the blend of 85% diesel, 10% biodiesel and 5%ethanol had the lowest HC emissions at the full load of the engine. The pure biodiesel produced lowest HC emissions among all fuels and were 52% lower than those of diesel fuel. The NO_X emissions increased with the increase of ethanol percentage in diesel-biodiesel-ethanol blends. The NO_X emissions of B10E5, B10E10 and B10E15 were 33.95%, 42.53% and 58.28% higher than those of the blend B10 at full load of the engine. The CO_2 emissions increased with load for all the fuel modes. The CO_2 emissions of B100, B10, B10E5, B10E10 and B10E15 were slightly higher than those of diesel fuel. The CO_2 emissions increased by 1.03%, 1.91% and 2.94% respectively with 5%, 10% and 15% of ethanol in diesel-biodiesel-ethanol blends. The unused oxygen emissions reduced with load for all the fuel modes. The unused O_2 emissions of biodiesel and the blend B10 were 19.2% and 4.8% lower than those of diesel fuel. The O_2 emissions reduced with 5% addition of ethanol and increased with 10% and15% of ethanol in diesel-biodiesel-ethanol blends. The O_2 emissions reduced by 0.8% with the blend B10E5 and increased by 1.6% and 4.8% respectively with the blends B10E10 and B10E15 at the full load of the engine. The smoke opacity of biodiesel was 27.93% higher than that of diesel fuel at full load of the engine. The smoke opacity of the blend B10 was 6.6% higher than that of the diesel fuel but 16.66% lower than that of the biodiesel at full load of the engine. The smoke Opacity reduced with increase of ethanol percentage in diesel-biodiesel-ethanol blends. The smoke opacity of the blend B10E5 was 2.55% higher but with the blends B10E10 and B10E15 respectively 1.7% and 5.11% lower than that of the diesel fuel at the full load of the engine.

10. Arun Pattanashetti, Praveen A. Harari, Ghadge S. S., Bhagwat V. A

Conducted experiments on effect of exhaust gas recirculation on the performance and emission characteristics of CI engine fuelled with diesel – compressed biogas and ROME – compressed biogas. In this work, an experimental work had been carried out to analyze the performance, and emission characteristics of diesel engine by varying the EGR of 5% and 10% when fuelled with diesel – CBG and ROME – CBG at 80% and 100% load.

Results showed that, BTE increases with increase in EGR rate. HC emissions were increases with increase in load and EGR rate. The CO emissions were increases with increase in load and EGR rate. NO_X decreases with increase in EGR rate. The smoke increases slightly as the EGR rates increases.

3. CONCLUSION

Rice bran oil biodiesel satisfies the important fuel properties as per ASTM specification of biodiesel. Engine works smoothly on rice bran methyl ester with performance compared to diesel operation. The rice bran biodiesel can be successfully substituted as alternative fuel for CI engine.

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